

CLASSIFICATION CONFIDENTIAL

CENTRAL INTELLIGENCE AGENCY
INFORMATION FROM
FOREIGN DOCUMENTS OR RADIO BROADCASTS

COUNTRY USSR
SUBJECT Economic - Ore deposits
HOW PUBLISHED Monthly periodical
WHERE PUBLISHED Moscow
DATE PUBLISHED Oct 1947
LANGUAGE Russian

DATE DIST. 10/1/47

50X1-HUM

NO. OF PAGES 12

SUPPLEMENT TO
REPORT NO.

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SOURCE Sovetskaya Geologiya, No 27, 1947. (FDB Per Abs 74T51).MANGANESE ORE DEPOSITS ALONG THE USA RIVER

A. L. Dodin

[Figures referred to herein are appended]

The presence of manganese ores along the Usa River near the Ivanov mine was first mentioned in an article by V. S. Reutovskiy [5].

In 1931, Ye. I. Gorevanov discovered pebbles rich in manganese oxide (pyrolusite and psilomelane) near the Bann and Sukh springs in the Ivanov mine area and came to certain conclusions as to the metathetic genesis of the deposits.

In his description of the manganese ores of Western Siberia, A. A. Vasil'yev [1] referred to the manganese deposit as eluvial. He felt that this deposit merited detailed study and prospecting.

Notwithstanding such a favorable report, no proper attention was paid to it until 1939.

In 1939, while making a geological survey (scale 1:100,000) of the left bank of the Usa, south of the Ivanov mine, the author examined these manganese ore outcroppings and established a close connection between manganese mineralization, the genesis of which had not been previously determined, and the Cambrian limestone horizon containing archaeocyathus, first discovered by him in the Bann Spring area.

In October 1939, K. V. Radugin visited the Usa manganese deposit. After cutting several trenches he concluded that the origin of the ore was sedimentary and that there were vast resources of carbonaceous ores in this region. In his article [4], Radugin made a bold forecast as to the stratified character of the ores and the great resources of the Ivanov deposit. His article gave an impetus, in 1940, to prospecting.

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Prospecting was conducted by a party from the West Siberian Geological Institute under the direction of A. S. Mukhin from 1940 to 1943.

The geological structure of the Usa region is very complex. As can be seen from the appended geological map and profiles (Figure 1) prepared in 1939, the region is complex chiefly on account of igneous rock with underlying early Paleozoic, highly dislocated, sedimentary deposits. The volcanic sedimentary rock complex was faulted by intrusions of various ages and compositions.

The general geological profile of the region is shown by the stratigraphical profile in Figure 2.

The central part of the Usa region is complicated by Cambrian carbonaceous deposits. These form a very thick band stretching from the Ivanov mine in the north to Petrovka in the south (Figure 1).

Structurally these Cambrian deposits constitute a complex steep anticlinal fold, tilted here and there toward the west, with an almost due southerly trend. At the center of the anticline there are dark marbles, almost black in places, as well as dolomitized limestones which often contain layers of argillaceous shale.

The very lowest horizons of carbonaceous deposits pertaining, in our opinion, to the Lower Cambrian were discovered along the Usa River near the Ivanov mine, along the Tumuyas River, and in the vicinity of the Petrov Mine. In the neighborhood of the latter, the chief outcropping was dark grey coarsely crystallized marbles. Patches of finely or medium crystallized light marbles were encountered. Usually their lamination was a distinctive trait, but sometimes they were solidly crystallized. Under the microscope they showed a uniformly granulated structure and were composed of aggregates of calcite around which a small admixture of fine quartz grains and flakes of sericite and chlorite was often observed.

On the eastern slope of the Sekvelass pass, in the direction of the M. Tumuyas River, dark, finely stratified bituminous marbles were observed. The strata dipped westward at an angle of 65 - 75°. In an easterly direction these finely stratified marbles were replaced by dark grey solidly crystallized marbles, which in turn gave way to light grey marbles with a strong smell of hydrogen sulfide. The strike of these limestone formations is 340° northwest; the dip to the southwest is at an angle of 70 - 75°. Lower on the slope, apparently on the edge of the ravine, these marbles give place to green chlorite shales occurring with a northwesterly strike (340°) and a 70 - 75° dip to the southwest.

In this district, a zone of dislocation runs between the marbles and the extremely crumpled green chlorite strata.

Skirting the Usa and the Tumuyas rivers, in the center of the anticline, dark marbled limestones and marbles crop out now and then with doubtful algae (oncolites). The strike of the strata is to the northwest (340° - 360°) the dip is largely eastward at an angle of 75 - 85°.

Mining operations in the western part of the ore-bearing horizon revealed an eastern subaerial wall of dark limestones. Traces of scouring on these rocks have been clearly established in the form of sporadic occurrences of limestones conglomerates. Judged by the underlying strata, the development of these dark marbles and dolomitized limestones is Lower Cambrian -- probably the upper part. The width of this part exceeds 1,000 meters.

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Actually, the ore-bearing horizon of the Usa deposit lies above the Lower Cambrian marbles. This horizon was uncovered by mining operations and was mapped by A. S. Mikhlin [5].

The western contact of the ore-bearing horizon and the basement marbles are very abrupt and fall southward at an angle of 70 - 80°. The contact is quite winding and is often accompanied by seams of dark basement-marble conglomerates.

The ore-bearing horizon is complicated by manganese-ore strata interstratified with oreless or slightly mineralized limestone. Here and there the limestone contains organic remains. Along the strike the width of the pure limestones grows comparatively greater while that of the ore strata decreases. In general, to the north and south the ore-bearing horizon is of a considerable extent, far beyond expectations from prospecting the right-bank section of the deposit. The width of the ore-bearing horizon is approximately 125 to 150 meters.

The eastern contact of the ore-bearing horizon, like the western contact, dips southward at an angle of 70 - 80° and gradually gives way to light marbled limestones.

The light limestone layer is complicated by uniform stratified varieties among which the detritus of archaeocyathus and algae are found.

We ascertained that there was an archaeocyathic algal shelf 400 meters above the under side of the stratum near the mouth of Barn Spring. In 1940 we discovered paleontological remains on the weathered surface of the marbled limestones forming rocky ledges on the left bank of the Usa River near the Ivanov mine. In this district, on the basis of archaeocyathus discovered, it is possible to distinguish two horizons of archaeocyathic limestones, very close together, but somewhat differentiated by the passage of time. Among the archaeocyathus we collected in the lower horizon, A. G. Vologdin identified Coscinocyathidae in a larval state of development and at least four types of the species Archaeocyathus Bill.

According to their general appearance, some types were close to the type described by A. G. Vologdin from the region of the N. Tersa, where their development was identified as intermediate between Lower and Middle Cambrian.

In this lower horizon conservoid reef-building algae were found, among which A. G. Vologdin identified Epiphyton Grande; Gordon, Epiphyton Fruticosum; Vologdin, Epiphyton Publitschenkovi Vologdin; and an ordinary specimen of Epiphyton Fasciculatum Chapman.

At 100 - 150 meters, and even higher above the horizon described above, we collected from analogous marbled limestones with the same eastward dip, fossils and algae, among which A. G. Vologdin identified Labyrinthomorpha sp. (Lab. Tolli Vologdin), Protopharetra (cf. Spelunca Vologdin, Protopharetra sp.), Tersia sp. (Tersia Filiformis Vologdin), Spirocycathus sp., Archaeocyathus cf. Tomicus Vologdin, Archaeocyathus sp., Loculocyathus sp., Asteroocyathus cf. Longus Vologdin, Coscinocyathus aff. Howelli Vologdin, Coscinocyathus sp. 1, Coscinocyathus sp. 2, Rhabdocycathus sp. nov.

In addition to the above algae occurring in the first horizon, Rehalais sp. and Chabakovia sp. were identified.

One interesting fact should be noted: in identifying the fossils we collected in the second horizon, A. G. Vologdin pointed out that in this profile, compared with the first horizon, they occurred at a greater height.

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In this case the complete coincidence of the stratigraphic and paleontological data conclusively proves the correctness of our view of the anticlinal stratification of the Usa carbonaceous layer and the associated eastward dip of the eastern side of the fold, in which side the eastern of all younger horizons, is in accordance with the movement to the east.

The most characteristic types of the above-mentioned archaeocyathid group are the *Asterocyathus* cf. *Longus*, identified in the Gavrilov limestone stratum at Salair and the *Coscinoocyathus* cf. *Howelli*, comparable to the type from the upper part of the Torgashin stratum.

Labyrinthomorpha sp. is very similar to the one identified as *Labyrinthomorpha* Tolli Vologdin by E. V. Toll in Torgashin limestone, and by A. G. Vologdin in the upper part of the Kameshkov horizon.

Hence, all the flora and fauna mentioned point to a transitional development of these limestones from Lower to Middle Cambrian. In all probability both the horizons identified by us belong to the lower horizon of Middle Cambrian.

On additional trips made in this region in 1940, we obtained new data revealing a wide range of archaeocyathic and algal reef limestones in the carbonaceous stratum of the Usa region. In particular, we found archaeocyathus among the limestone heaps in the central part of the Sukh ravine opening into the Usa near the mouth of the Tumuyas River, as well as on the left bank of the Tumuyas among dolomitized limestones and marbles.

In making a detailed survey (scale 1:10,000) K. V. Radugin also uncovered archaeocyathus among the limestones discovered along the Pryam ravine opening into the Tumuyas 1.5 kilometers from its mouth.

By careful assembly and analysis of Paleontological data it will doubtless be possible to distinguish new horizons in the Middle Cambrian stratum of the Usa region, identified from the paleontological standpoint.

The width of the limestone stratum of archaeocyathic formations located along the Usa and Tumuyas cuts, where the east side of the anticlinal fold is easily seen, approximates 1,000 - 1,200 meters.

Similar data was obtained in determining the width of the Middle Cambrian limestones on the west side of the anticlinal fold, which could be clearly traced on the right bank of the Usa opposite the Tumuyas confluence.

It should be noted that until recently K. V. Radugin, as well as A. S. Mikhin, objected to my concept of the anticlinal structure of the region and to my equating the ore-bearing horizon to the eastern side of the anticline in the lower horizons of the Middle Cambrian. In K. V. Radugin's opinion ⁴, the ore bearing horizon occurred in a narrow, extremely restricted, synclinal fold, bordering on earlier Lower Cambrian and Proterozoic deposits. In particular, light marbles and dolomitized limestone, discovered on the right bank of the Usa opposite the Tumuyas confluence and forming, according to our data, the west side of the Usa anticline, were referred to the Proterozoic era by K. V. Radugin. The inaccuracy of such a reference stems from an erroneous idea of the structure of the region in which the deposit is located.

When A. G. Vologdin visited the Usa region in 1944, he discovered among these marbles archaeocyathus and algae similar to our 1939 collections on the east side of the Usa anticline. This find emphasized the correctness of the conclusions we reached in 1939: that the Usa-Tumuyas stratum of marbles and dolomitized limestones is related to the lower horizon of the Middle Cambrian (Usa stratum), forming the west side of the complete Usa anticline.

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In a southerly direction, Middle Cambrian marbles were identified as the sources of the Sekvalas River, where they formed the west side of the anticline, and in the Petrov Mine region, where they formed the east side of the anticline.

It is characteristic that the ore-bearing horizon of the Petrov manganese ore deposit which I discovered in 1941 [27] was also located on the border of Middle Cambrian limestones and Lower Cambrian basement marbles. In individual districts, limestones of the Middle Cambrian system have a brecciated texture, and in places contain a small amount of siliceous concretions. Almost all limestones are characterized by a distinct schistosity and great friability. Ferric oxides, as well as manganese, can often be discerned along the cracks. Limestone specimens taken from rocky outcroppings, uncovered near the Ivanov mine and containing archaeocyathus, consisted of finely granulated calcite contaminated by clay products and oxides of mineral ores. The mineral ores were in general related to fissures. Certain cracks were filled in cross section by coarse crystals and calcite aggregates. Layers of archaeocyathus which came to light have also crystallized considerably. In quartzose varieties of limestone, grains of quartz were observed in the midst of the calcite. It is possible that in isolated specimens the quartz was primary.

Stratigraphically, tufaceous sedimentary stratum of heterogeneous composition occurred transgressively, above the limestone of archaeocyathic formation. At the base of this stratum, directly on the limestone, there was a bed of pinkish-violet tuff conglomerates, consisting of rounded dark grey limestone detritus and porphyry detritus, cemented together by tufaceous and argillaceous sandstone substances.

The patch of conglomerates attained a width of 100 to 120 meters. The direct transgressive pressure of these conglomerates on the archaeocyathic limestone horizons is clearly observable from the excellent profiles of the banks of the Usa near the Ivanov mine and of the left bank of the B. Tumuyas (Figure 2). Near the mine office it is evident that the basement limestones dip eastward at an angle of 70° and that the conglomerates covering them also dip eastward at an angle of 45° - 50° .

Limestone detritus contained in the conglomerates indicates the occurrence of scouring in the lower horizons of the Middle Cambrian carbonaceous deposits, while the porphyry detritus may have been brought about in either of two ways: because of dikes of diabasic porphyries intersecting the limestone, or because of a completely eroded porphyritic blanket deposit which never pressed on the limestone of the archaeocyathic formation. Finely laminated violet tuff sandstone overlies the conglomerates. These rocks, with an eastward dip at an angle of 75° - 80° , have been traced for 500 to 600 meters on the left bank of the B. Tumuyas River. The apparent width of this patch of violet tufaceous, calcareous sandstone amounts to 350 - 400 meters. A microscopic examination of these specimens showed that they consisted chiefly of fine, acute angled grains of quartz, mica fragments, chlorite and calcite aggregates, cemented together by a quartz, clayey, brown ferrous cement. Among the accessory minerals present were zircon and titanomagnetite.

The high content of finely powdered iron obviously accounts for the violet coloration of these rocks. The red stratum of tuff detrital and schistose rocks described earlier, in all probability, developed in the middle of the Middle Cambrian, since it overlays the limestone characterized by fauna of the lower horizons of the Middle Cambrian and was, in its turn, covered by a stratum of greenstone tuff-porphyrity, referred to the upper parts of the Middle Cambrian.

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It should be noted that the red stratum of Middle Cambrian age which we identified in the Usa region is an important factor in the reconstruction of paleogeographic conditions of this period.

The short description given of the stratigraphic profile of the area forming the central part of the Usa region graphically demonstrates the anticlinal structure of this district which is situated on the western slope of the Kuznetsk Alatau.

The ore-bearing horizon of the Usa and Petrov manganese ore deposits is closely connected with the carbonaceous detritus of the lower horizons of the Middle Cambrian, which lay over basement marbles of the Lower Cambrian along with a basal conglomerate without apparent angular nonconformity.

The outcropping of manganese ore discovered by the geologist V. M. Lyakhnitskiy, on the Great Usa, 6 kilometers from its mouth, aroused great interest. K. V. Radugin's geological map shows that these ores are embedded in the midst of Proterozoic marbles and shales. But in our opinion they are also located in the lower horizons of Middle Cambrian marbles. It is highly probable that here the Great Usa ores occur on the west side of the anticlinal structure. This hypothesis, confirmed by the general structure of the Usa region, is of great practical significance and opens wider prospects for the Usa manganese ore region.

The section of the Usa manganese deposit already explored, situated on the eastern slope of the watershed between the Great Usa and the Usa, is shaped like an irregular ore lens stretching 1,200 meters in a northeasterly (350°) direction from the Usa valley to the Magnetic Mountains with an average breadth of about 120 meters. The character of the lens toward the north, where oreless limestone produces an abrupt change in the ore horizon at its maximum width, is not very clear. It is possible that a disjunctive dislocation, masked by detritus, runs along the northern border of the ore body.

The southern continuation of the so-called right-bank part of the deposit, already explored, is on the left bank of the Usa.

In 1929, oxidized psilomelane ore detritus was found by boring on the left terrace along the line of the strike of the ore horizon. Farther south, along the slope of the watershed ridge toward the Lumbyas, extending for 4 kilometers to Azhegol brook, psilomelane ore detritus was encountered sporadically. Hence, the total observed length of the ore horizon exceeded 5 kilometers. Prospecting in 1941, on the left slope of the Usa valley, brought to light three ore beds, 750, 200, and 800 meters long, within a distance of 3 kilometers. We must remark that, according to our reasoning, in the left-bank section of the deposit, embracing the Usa valley and the watershed which has been worn smooth but is comparatively sloping, there is every condition needed for a concentration of rich oxidized manganese ores suitable for the extraction of ferromanganese.

The composition of the left-bank ore body is fairly complicated and, in spite of the many channels passing through it, not completely explained. Frequent interstratifications of various types of ore and slightly mineralized limestones were observed inside this ore body, as well as completely oreless light marbles and grey "silicillites" with rare seams of shale. In the midst of the ore horizon there are dikes of diabasic porphyry, usually stretching in the same direction as the strike of the carbonaceous band. The width of the dikes is 0.5 to 10 meters.

As we noted earlier, the western contact of the ore horizon is winding, depending on its unconformable pressure on the Lower Cambrian basement marbles. In various cuttings in the west section of the deposit, light marble-containing conglomerates were discovered. This layer is composed of acute-angled detritus of black and grey marbles, held together by a cement of limestone and sandstone and sometimes of concentrated manganese.

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Probably, the unconformable pressure, depends upon the position of the deposit at the limit of the Lower and Middle Cambrian.

The Middle Cambrian limestones, containing archaeozooids, faunas, etc., are in a shallow basin with great reefs. The composition and structure of the ore-bearing section of the Middle Cambrian profile indicate the development of an interreef laguna facet alternating with facets in the dip of pure stromatolite and macrobiogenic depositions.

The established stratified character of the mineralization and the presence of pea ores leave no doubt as to the sedimentary genesis of these carbonaceous manganese ores. The eastward dip, explained above, of the western and eastern contacts of the ore horizon, pressing upon dark Middle Cambrian marbles (based on a basalt conglomerate) and changing in an upward direction through the section of Middle Cambrian limestones with characteristic faunas, proves the accuracy of our conclusions as to the monoclinical deposition of the ore horizon on the east side of the Usa anticline near its center.

The hypothesis of a synclinal structure of the ore formation, advanced by K. V. Radugin and laid down as a basis for prospecting, does not agree with the facts. Such a theory, without any possible basis, would impose limits on the prospects of the great manganese ore region of the Usa.

At present, after the prospecting operations on the right-bank section of the deposit, carried out by the ZSTU party under the direction of A. S. Mukhin, and after the mineralogical analysis of the ores made by R. V. Getseva, two basic classes of ores have been distinguished -- chlorite carbonates and limestones (manganocalcites).

Chlorite-carbonate or, as they were called earlier, silico-carbonate ores are the chief industrial type of ore in this rich deposit. Macroscopically they suggest finely laminated jasperoid rocks or dolomites shading from dark gray to black. Under the microscope they display a finely dispersed and, at times, oolitic structure. Their chief constituents are carbonates (70 to 85 percent) and chlorite.

The comparatively rich ores in this class make up the central part of the ore formation in the right-bank section of the Usa deposit. They are bounded on the west and east by poor limestone ores.

In outer appearance these limestone ores recall the ordinary dark gray or black limestone. Under the microscope such ores generally consist of fine round grains of manganocalcite with a slight admixture of clayey and carbonaceous matter. They contain from 3 to 9 percent of manganese and change gradually into oreless manganese limestone.

In the lower (western) part of the ore-bearing formation sheets of silico-argillaceous ore were isolated by A. S. Mukhin. They suggested greenish-gray shale, brown in places. Under the microscope they consisted of finely granulated silica, some spicules of sponge, clayey matter, and varying amounts of manganocalcite. The manganese content in these ores varied between 5 and 15 percent and the silica between 40 and 60 percent.

It is interesting that we discovered practically identical clayey siliceous ores in the Alexandrov Mine region, where they also occur in the lower part of a Middle Cambrian stratum.

The surface area of the deposit has a well-developed zone of oxidation, varying in depth between one or 2 (for close-grained ores) and 10 meters (for very crumbling varieties near the tectonic zone).

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The oxidized parts are represented by fine (from 0.05 to 0.1 mm) meter crusts of manganese hydroxides along the fractures, as well as by ores consisting mainly of psilomelane.

Along the disjunctive displacements fairly wide layers of ores are observed, represented by a dark brown, black, and sometimes even reddish ochreous mass, in which various fragments of psilomelane are included as well as slightly oxidized pieces of ore. The ores in the oxidation zone are greatly enriched by manganese. They are the richest type of ore in the deposit but there is not a very large amount.

A survey of core material, brought to my attention by A. B. Mukhin, and our microscopic examination of various ore samples makes it possible to speak about the considerable metamorphism of manganese ore.

The hydrothermal processes accompanying metamorphism are shown by the formation of seams and various pockets of pinkish manganese carbonates (rhodochrosite) as well as of quartz calcite seams together with chlorite. Moreover, in various types of ore, sulfide impregnations may be observed---pyrites, marcasite, arsenopyrite and chalcopyrite.

The metamorphism of limestone and ores within the ore body is also evidenced by silification and the formation of rhodomite. Dolomitization was observed in different districts.

Metasomatic silification often makes its appearance in the form of black siliceous bands, suggesting primary chlorite carbonate ores.

Different varieties of siliceous ore were probably formed as a result of silification of primary ores with some additional manganese.

The following conclusions may be stated in closing:

The region of the deposit is an anticlinal structure at the core of which there are dark Middle Cambrian marbles. The sides are compounded with a band of Middle Cambrian carbonates.

The ore-bearing formation is related to a lower horizon of Middle Cambrian marbles.

The right-bank section of the deposit, as shown by prospecting, overlies the east side of an anticlinal structure. Its composition permits the assumption that the presence of the same ore-bearing formation with an industrial manganese concentration is possible on the west side of the anticline.

Chlorite carbonate ores form the main industrial class in the right-bank section which has been prospected.

In addition to this comparatively rich class of ore, there are also limestone ores with a manganese content running between 2 to 3 and 10 percent (average content 6 percent).

The question of utilizing these poor ores must be raised in connection with the use of limestone for smelting and for blast furnaces in the Stalin Metallurgical Plant.

The manganese resources, already located, indicate the vast scale of the Usa deposit. It is extremely important in the national economy.

Simultaneously with utilization of the right-bank section of the already prospected deposit, prospecting should be carried out on the left-bank section between the Usa valley and the sources of Azhegol springs. There is good reason to suppose that in this section, worn smooth by time, there are

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great oxidized ore resources with a considerable sulfur content.

Further development of the Usa manganese resources of the discovery of new ore leases among the deposits overlying the sides of the Usa anticlinal structure is possible because of my discovery in the Petrovsk area of an ore deposit related to Middle and Lower Cambrian deposits.

The greatest attention should be paid to the lower horizon of the Cambrian limestones (containing archaocyathus), among which the formation of the Usa manganese deposit is included.

[Appended figures follow.]

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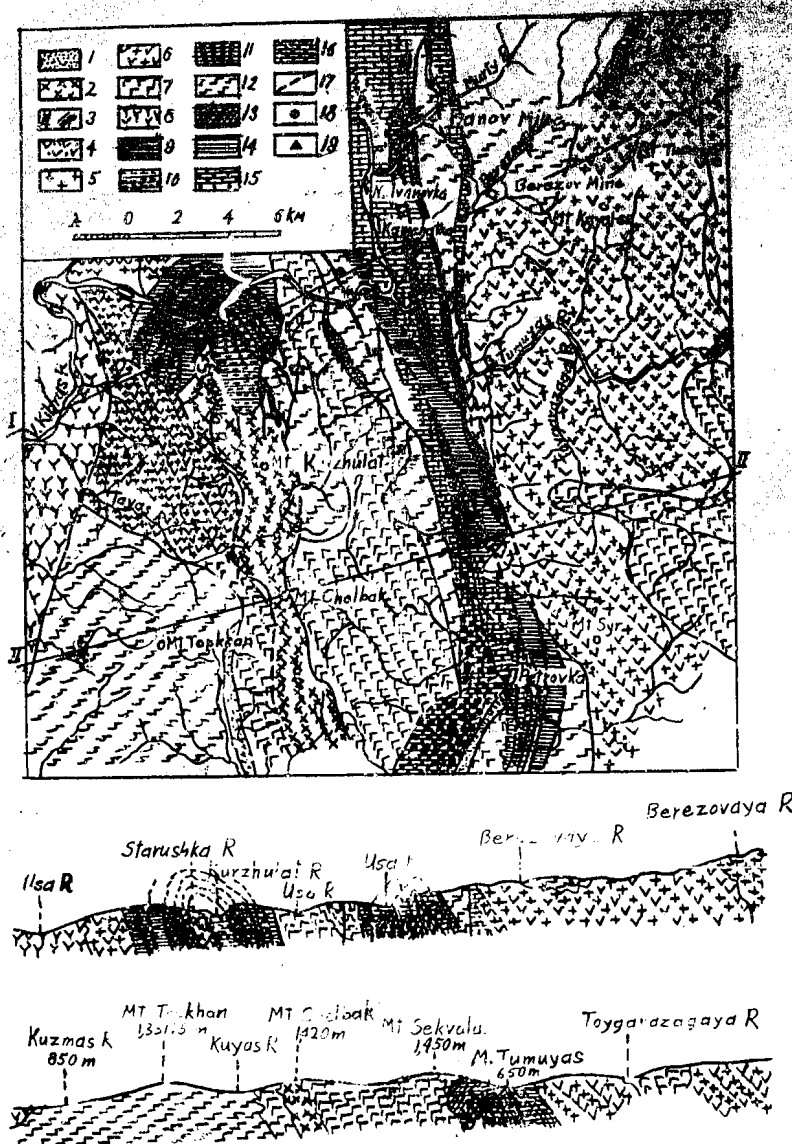


Figure 1. Geological map of the Usa region of Kuznets Alatau --

(1) Quaternary deposits; (2) plagiogranites resembling aplite and pegmatite; (3-5) young Caledonian intrusions: (3) vein diabases and diabasis porphyries, (4) syenite porphyries and "pelvabergites," (5) porphyritic granites; (6-7) old Caledonian intrusions: (6) alkali syenites, granodiorites and diorites, (7) gabbro diorites, gabbro pyroxenites and hornblendes; (8) violet porphyries and porphyries; (9) microgneisses and quartz; (10) amphibolites and amphibolite sills; (11) marbled limestones; (12) greenstone buff-porphyrific stratum; (13) calciferous sandstones and slates; (14) chlorite-sericite slates with patches of marble; (15) limestones with algae and archaeocyathi; (16) crystallized limestones and marbles; (17) lines of tectonic displacement; (18-19) deposits; (18) manganese, (19) iron

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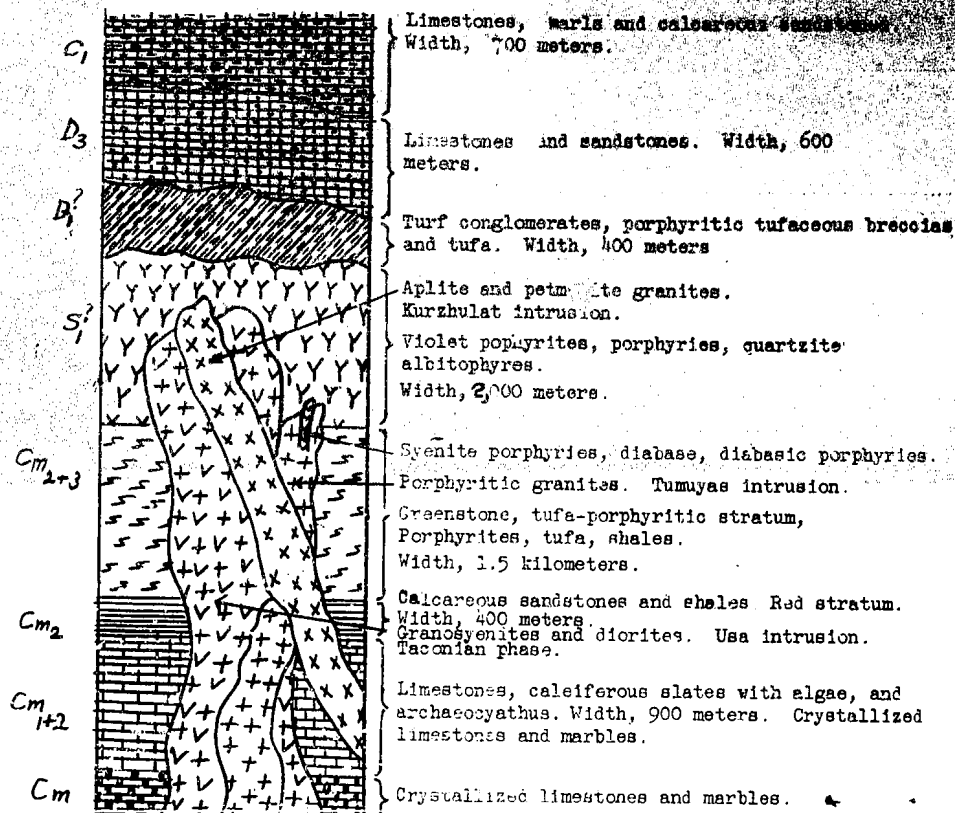


Figure 2. Example of Stratification of Usa Region in the Kuznetsk Alatau.

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